

## Hemisphere Dominance in Aphasia -“Crossed Aphasia”-

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### INTRODUCTION

Broca (1865)<sup>1)</sup> happened to find a small lesion of encephalomalacia in the left inferior frontal gyrus of 2 patients with aphasia he was investigating. This finding led him to identify the site with the center which is concerned in speech function and also to state that man speaks with the left hemisphere. Based on his ample experience in autopsy, Bouillaud (1865) also elucidated the relationship between the speech center and handedness<sup>2)</sup>. The left hemisphere which is contralateral to the hand that works has since been known as the leading (Jackson) or the major hemisphere (Nielsen). Such a viewpoint has become established in the study of aphasia. On the other hand, however, aphasia associated with left-handedness has also come into question while a number of investigations have been made concerning the function of the right hemisphere as the site of speech center (Luria<sup>3)</sup>, Conrad<sup>4)</sup>, Subirana<sup>5)</sup>, Hécaen et al.<sup>6)</sup>, Ohashi<sup>7)</sup> etc.). There are also some studies available, although extremely limited in number, as to “crossed aphasia” which was first documented by Bramwell (1899)<sup>8)</sup>, i.e., aphasia due to a lesion in the hemisphere which is collateral to the hand that works (Mendel<sup>9)</sup>, Marinesco et al.<sup>10)</sup>, Imura et al.<sup>11)</sup>, Marcie et al.<sup>12)</sup>, Boller et al.<sup>13)</sup>, Brown et al.<sup>14)</sup> and Ito et al.<sup>15)</sup>).

Illustrated below is a case of crossed aphasia associated with right-handedness. It is hoped that this case report will add to the few materials so far documented in this field and be of help in clarifying the relationship between handedness and brainedness.

### REPORT OF A CASE

A male public official aged 42 and graduated from a college of science, who had been right-handed with dominant use of the right eye

and leg since his childhood.

Previous history: Hospitalized for 3 months because of infiltration of the lung at age 23. Fell down violently while driving a motor bicycle in Feb. of the year when he was 41 years of age. The resultant fracture of the right clavicle required 3 weeks of hospital care. When the accident happened, he suffered no disturbance of consciousness but was able to go to the hospital on foot. No abnormalities in the head were demonstrated during his hospital stay in examinations including CSF,, EEG, echogram and cranial x-rays.

Family history: His six siblings were all alive and healthy except the eldest sister (aged 64) who suffered from hypertension. None of the members of his family inclusive of his 2 healthy daughters were lefthanded.

Tastes and hobbies: Had no particular taste worth mentioning. No habit of drinking. Smoking: 20 cigarettes a day.

Present history: In Nov. of the year when he was 42 years of age, while taking an official trip on a fairly hard schedule with his fellow official, he suddenly fell down at the entrance of a hotel in the evening. He had salivation with motor paralysis of the left limbs. The onset was so abrupt that his fellow believed he was playing. A physician came to see him 5 minutes after the attack, when the patient had a clear consciousness, being able to write in his notebook in correct lettering with his right hand that he wanted to go to stool by himself and that he had paralysis of the mouth, hands and legs.

The patient was admitted at once. Had vomiting with urinary incontinence 2 hours after the attack. Although he had a clear consciousness all the while, there was evidence of elevated cerebrospinal pressure with bloody liquor, leading to the diagnosis of subarachnoidal hemorrhage. While in the ward, the patient was able to understand those who were around him but unable to speak himself, his will being expressed by gestures or writing. Then transferred to the 2nd Dept. of Surgery, Yamaguchi University School of Medicine 3 weeks after the onset because of so marked incapacity for attention as to be unable to remember even what happened a minute before. The findings upon admission to our clinic are briefly outlined here together with the subsequent laboratory and surgical findings, for further details of which the reader is referred to a report of Higashi et al. entitled "Spontaneous intracerebral hematoma"<sup>16</sup>.

Findings upon admission to the surgical ward: The patient had a clear consciousness. He replied to our questions with gestures and writ-

ing, being apparently able to understand us to a substantial extent. There was no abnormality in the pupils or eye-ground, now paralysis of cerebral nerves. Left-sided hemiplegia was present with accentuated left deep tendon reflex, positive left knee and ankle clonus reflexes, absent left abdominal reflex and sensory paralysis of the left limbs.

Laboratory findings: Mild leukocytosis was present but liver and kidney function tests were within normal limits. Blood pressure 120/80 mmHg. Lumbar puncture revealed xanthochromic liquor with an initial pressure of 240 mmH<sub>2</sub>O, a cell count of 18/3, a slightly increased protein content and negative Wassermann's reaction. The cerebral angiogram taken at a right carotid artery showed marked downward displacement of the angiographic Sylvian point, Sylvian group of arteries and the Sylvian triangle, with the parietal branch of A. angularis straightened up. An abnormal shadow suggestive of a small angioma was also present in a segment of a branch of the right middle cerebral artery, where, in the venous phase, there were some abnormal veins developing. The pneumoencephalogram showed enlarged right and anterior horn of the ventricle with deviation to the left of the median line structure. The right anterior horn of the ventricle, when viewed laterally, was found deviating downward posteriorly. The electroencephalogram was generally characterized by frequent abnormal slow waves with lazy activity in the right parietal and temporal regions.

Surgical findings and subsequent course: On the 34th day of affection the patient underwent craniotomy under the diagnosis of intracerebral hematoma in the right parietal lobe. In the parietal region the cortex looked somewhat yellowish on the surface and the gyri were flattened. A small incision was made into the cortex of the posterior central gyrus. At a depth of approximately 5 mm the capsule of a hematoma was reached. The hematoma looked blackish brown, containing approximately 100 ml of blood clot. The hematoma then excised was as large as about 8×5×4 cm. It was oval in shape, being longer anteroposteriorly, with its center located roughly under the cortex deep in Rolando's fissure. The capsule fell short of covering the entire surface of the hematoma and was lined only by necrotic brain tissue. No tumor was present, either macroscopically or histologically, around the space of the hematoma, nor was there any communication between the hematoma and the ventricle, any angioma or any malformation of blood vessels.

In the night of the day when the patient underwent the operation, he suddenly spoke something meaningless linguistically, repeating short syllables or words. Such a condition of the patient lasted about 6 hours

or until the next morning. Three days postoperatively he was capable of answering questions in a simple way, although he spoke so lispingly in altered vocal sounds and in an unaccented, monotonous, flat and leisurely fashion as if he had been a child. On the 5th postoperative day he had his left leg working to a slight extent. On the 9th postoperative day he became to complain of his desiring to void. There was a gradual improvement subsequently in his speech function and the motor function of his affected leg, but no sign of recovery from paralysis of the left upper limb. The cerebral angiogram taken postoperatively showed cerebral vessels running in an almost normal fashion. The abnormal shadow suggestive of an angioma had also been cleared. Postoperative pneumoventriculography demonstrated the presence of porencephaly at the site of the hematoma excised.

The patient saw us at our outpatient clinic on the 62nd day of affection.

Neurological findings: There was slight downward deviation of the left angle of the mouth with shallow left nasolabial sulcus and slight asymmetry of the face. No motor paralysis of the tongue was present: the patient was able to put out the tongue or smack the lips. Nor was there any abnormality of pharyngeal reflex. The pupils were normal; both light and accommodation reflexes were prompt and complete. Neither limitation of ocular movement nor nystagmus was present. The patient was able to frown. Also able to stand up although in no normal way because of incomplete left-sided hemiplegia, but unable to walk. Physiological tendon reflexes were accentuated with positive ankle clonus reflex on the left side. No difference between the right and left was noted in abdominal reflex, which was incomplete. Cremasteric reflex was absent with dullness of sensations (pain, touch, temperature and vibration) on the left side of the body. There was no dysarthria, nor any abnormalities in visual acuity or field. Senses of taste and smell were within normal limits as hearing.

Psychiatric findings: The patient had a clear consciousness. He was in a good humor and cooperative in psychiatric examination. There was marked emotional incontinence with features suggestive of mild dementia but without disorientation for time, place or men. He said to a member of his family at night that he would be taken away by the Air Force and that someone robbed him of a medicine at his bedside. This episode suggests pathological experiences or a lowered level of consciousness at night which he might have or suffer transiently.

Cerebral pathological findings: With improved voluntary speech, the

patient was markedly relieved of the initial state of word-muteness. He was able to tell his name fluently but stuttered at the first syllable of his address or birth date. He pronounced articulately but in slightly altered vocal sounds, at somewhat sluggish tempo, and in a monotonous, flat fashion. There was marked anomia. The patient often used demonstrative pronouns but without agrammatism or improper use of particles, auxiliary verbs or verbs. His spontaneous speech was featured partly by stereotyped wording and partly by intentional language of propositional value. There was periphasia or paraphasia in naming articles of daily use, but jargon-aphasia was absent. The patient spoke a series of words of related meaning with omissions or in mistaken order. He was able to repeat monosyllables, words and short sentences but could repeat somewhat long sentences only with much omission and perseveration.

The patient understood speech rather satisfactorily and was able to indicate things or act in a simple way (close his eyes or put out his tongue) just as ordered orally. He was successful in the "three pieces of paper test" (P. Marie). There was no perseveration of action. He could read loudly katakana and hiragana, letter by letter, in a correct way but sometimes with perseveration. He was able to grasp the meaning of words although somewhat slow in doing so. He could apprehend the meaning of Chinese characters less satisfactorily, which he read loudly letter by letter. The alphabet was read correctly. Short English words were pronounced in an almost correct way after component letters were read one by one. He wrote swiftly with his right hand without failure or mistake, but often failed in writing sentences as dictated because of poor understanding. Instead he sketched what was dictated (Suzuki-Binet, Question 36, for example). Able to copy letters or figures, even if fairly complicated.

The patient cognized his fingers or the right and left in a somewhat incorrect manner: he was found embarrassed with a mirror image developing while taking the hand-eye-ear test (Head). He was able to read numbers of up to 6 figures correctly but sometimes had difficulty in adding or subtracting, even if with figures, numbers of 2 or more figures. Characteristically, he could often name, select or indicate colors correctly when he did so not in Japanese but in English.

Hemiplegia prevented him from some intransitive movements: whistling and pouting. On the other hand, he was able to open or close his eyes or open his mouth. Also capable of moving his head, trunk or right limbs in a simple manner or mimicking motions.

The patient was capable of transitive movements even without any

object but with a trait of arbitrariness. He was able to read the clock or draw a cube in a free fashion. Had no disturbance of orientation while in the ward or at home, nor geographic disorientation. Able to compose simple geometric figures of match sticks with his right hand. The findings described above rule out the possibility of agnosia or apraxia.

To sum up, there were disturbances of verbal expression coming to the foreground in this patient, which were featured by extremely infrequent voluntary speech, loss of fluency of speech, altered vocal sounds, anomia, periphasia, paraphasia and perseveration. In addition, the patient had somewhat pronounced defects in the ability to repeat, to read loudly, to write as dictated and to calculate numbers. These signs and symptoms led us to the diagnosis of Broca's aphasia. The patient had no agnosia or apraxia.

Subsequent course: Discharged on the 30th postoperative day, the patient is now under training for functional recovery at home. No marked improvement in speech function has resulted up to the present.

## DISCUSSION

The patient had an oval intracerebral hematoma extending antero-posteriorly mainly beneath the cortex deep in the right Rolando's fissure, along with a lesion of malacia and necrosis of brain tissue deep in the hematoma. These changes are considered to be responsible for the disturbance of speech the patient had. In this case, the necessity of discriminating the disturbance of speech from anarthria should be taken into account. However, cerebral pathological evidence for disturbance of internal speech in this instance may warrant the diagnosis not of anarthria but of motor aphasia.

Now, the primary feature of this case is that the lesion was located in the right hemisphere of the patient who was constitutionally right-handed. It has been established in cerebral pathology that a dominant hemisphere is the one which is contralateral to the hand that works (Penfield)<sup>17)</sup>. Since a report of Bramwell<sup>8)</sup>, however, there have been a modest number of studies available concerning "crossed aphasia" which is due to a lesion located in the hemisphere collateral to the hand that works<sup>9-15)</sup>.

There are no simple, valid criteria for handedness which are generally accepted. Goodglass and Quadfasl<sup>18)</sup> believed it justifiable to determine the handedness of a subject according to what he states himself, whereas Chesher<sup>19)</sup> employed a somewhat objective criterion for this

purpose: the hand that is used for writing. More objective criteria were suggested by Kimura and Vasterwolf<sup>20)</sup>: writing, brushing teeth, combing, nailing, cutting bread, keying, striking a match and holding a tennis racket. They proposed to determine handedness according to whether the right or the left hand is predominantly used in writing and 6 or more of the other actions listed above. The patient was properly considered to be right-handed in all these respects. Also, the right eye and the right leg were in predominant use in this case.

Next, it comes into question which hemisphere is dominant in this case. In this respect there are early studies made by Jackson<sup>21)</sup>, followed by an electrophysiological investigation by Penfield et al.<sup>17)</sup> and Zollinger's work<sup>22)</sup> in corticectomized subjects. It has thus been believed that the left hemisphere is dominant in those who are righthanded. One method for determining which hemisphere is dominant is by performing "transient pharmacologic hemispherectomy" with sodium amytal infused in the internal carotid artery to examine whether transitory aphasic disturbance of speech ensues. (Wada et al.)<sup>23)</sup> Furthermore, cerebral pathological studies have been carried out in hemispherectomized patients or those with an extensive lesion in either hemisphere. It would be warrantable to attribute the left-sided hemiplegia in our patient to the intracerebral hematoma that was present in the right hemisphere. The aphasic disturbance of speech that developed simultaneously with the onset might be more reasonably be explained by a defect in the speech center than by elevated intracranial pressure with the resultant oppression or other physical effects on the center in the left hemisphere.

It has long been known that the right hemisphere as the subordinate one is also a site of speech function, a fact which has provided the subject for recent studies by Marcie et al.<sup>12)</sup> and Critchley<sup>24)</sup> reported manifestations of disturbed speech function in the right hemisphere include transitory dysarthria, lowered ability for literary expression, circumstantiality, expressions in a bizarre manner, disturbance of visual or auditory understanding, non-aphasic misnaming, inability to grasp the symbol or meaning of drawings, phonetic errors in mimicking language, perseveration, and difficulty in synthesizing words into a sentence. Not all of these signs or symptoms have been accepted (Hamanaka)<sup>2)</sup>.

The transient pathological experience our patient had postoperatively seems to have been due to a nocturnal fall in the level of consciousness. It may be, on the other hand, that the experience represented something like a dreamy state associated with a lesion in the right temporal lobe. Morbid experiences in patients with injury to the right hemisphere are said to be ordinarily in the form of visual hallucinations. (Hécaen<sup>25)</sup>,

Gloning et al.<sup>26)</sup>)

To what extent the severe emotional incontinence our patient had is related to the damage to the right hemisphere? Terzian<sup>27)</sup> infused sodium amytal into the right or subordinate hemisphere of a subject, to find him in euphoric or manic mood that ensued. It has been reported that emotional reaction varied according to whether there is a lesion in the right or left hemisphere (Gainotti)<sup>28)</sup>. Disturbances of high-level integrative functions including those of personality emerge only when both hemispheres are affected. (Hécaen & Ajuriaguerra)<sup>6)</sup>

A difference exists between the hemispheres as to the impact on memory or ability for learning: the dominant hemisphere is more concerned in verbal, and the subordinate one in non-verbal aspects (Lhermitte et al.)<sup>29)</sup>

Much of the knowledge pertaining to the disturbances of speech associated with injury to the thalamus or corpus striatum was gained in patients undergoing stereotaxic operation. The operation on the dominant side gives rise to motor or amnesic aphasia, whose prognosis is poorer than with the operation on the inferior side (Almgren et al.)<sup>30)</sup>.

The reported incidence of crossed aphasia among those who are right-handed with the right hemisphere dominant ranges somewhat widely from 0.4 to 11 per cent (Subirana<sup>5)</sup>, Ludwig<sup>31)</sup>, Zangwill<sup>32)</sup>, Roberts<sup>33)</sup>, Milner et al.<sup>34)</sup>). This is probably due to the dissimilarity of the criteria employed for handedness and brainedness, as pointed out by Ito et al.<sup>15)</sup>. There are some genetic predisposing factors involved in handedness. Not a few people are potentially left-handed. (Kennedy)<sup>35)</sup>. Moreover, the validity of the method of Wada et al.<sup>23)</sup> for the estimation of brainedness is somewhat debatable.

Finally, there is an interesting fact about our patient illustrated here. That is, the speech function pertaining to kana was less seriously disturbed in this patient than that relating to Chinese characters as hieroglyphics, contrary to the generally accepted opinion that Broca's aphasia more severely affects the former than the latter (Sakamoto)<sup>36)</sup>. It is believed that, in aphasia, a speech acquired later is generally disturbed more markedly while that learned earlier remains relatively unaffected. Interestingly, the speech of the alphabet or English words learned at the age of no less than 15 was disturbed only slightly in this patient, who made a good record in color-naming test, if not in Japanese but in English.



## SUMMARY

A 42-year-old male patient with cross aphasia due to essential intracerebral hematoma deep in the subcortical region of the right parietal lobe has been presented. Both the patient himself and all members of his family were right-handed.

Craniotomy disclosed an oval hematoma which was longer anteroposteriorly with its center located beneath the cortex deep in the right Rolando's fissure. The hematoma had a content of approximately 100 ml with its lower surface lined by necrotic brain tissue.

The resultant disturbance of speech was identified with Broca's aphasia, being featured by infrequent voluntary speech, loss of fluency of speech, altered vocal sounds, anomia, paraphasia, periphasia, perseveration, defects in repetition, loud-reading and writing as dictated, and miscalculation, with disturbance of verbal expression coming to the foreground.

The symptomatology of the disturbances of speech function corresponding to a lesion in the dominant and subordinate hemispheres was also discussed.

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